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## NEW SINGLE-PHASE ELECTRIC LOCOMOTIVES OF NORMAL FREQUENCY FOR THE HUNGARIAN STATE RAILROADS

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In 1934, the Budapest-Hegyeshalom double-track line (190 km) was electrified, using 50 cycle, 16 kv, single-phase current. Before World War II, it had 29 electric locomotives of the 1-D-1 (1-4-1) type and three electric locomotives of the F (0-6-0) type. The 1-D-1 locomotives, with a maximum speed of 100 km/hr, were intended for passenger and freight trains. The F locomotives (maximum speed 68.6 km/hr) were mainly used for coal trips of over 1,000 tons.

The designs of the two locomotives are basically the same. Equipment includes a synchronous phase converter, one traction motor, a starting rheostat, and an automatic regulator. The hourly ratings of the traction motors are identical -- 2,500 hp.

The transmission from the traction motor to the driving axles is of the lever type, using the so-called Kando frame and the usual coupling rods.

The 1-D-1 locomotive weighs 98 tons and the F, 94 tons.

Speed control is effected by altering the number of poles of the traction motor.

At present, the Hungarian railroads are building two single-phase electric locomotives of normal frequency which differ considerably from those described above. Their basic characteristics are as follows:

| | |
|---|---|
| Axle formula | Vo So |
| Axle load | 17 tons |
| Weight of electrical portion | 42 tons |
| Weight of mechanical portion | 40 tons |
| Weight of other equipment | 3 tons |
| Total weight | 85 tons |
| Diameter of wheels | 1,040 mm |
| No of traction motors | 5 |



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The operating data for these locomotives is given in the table below.

| Speed (km/hr) | 25 | 50 | 75 | 100 | 125 |
|---|---|---|---|---|---|
| Maximum instantaneous traction force (tons) | 21 | 21 | 16 | 12 | 9.6 |
| Hourly traction force (tons) | 13.5 | 13.5 | 10.8 | 8.6 | 6.9 |
| Hourly power on rim (hp) | 1250 | 2500 | 3000 | 3200 | 3200 |

The chief difference between these new-type locomotives and their predecessors is the use of individual instead of group drive. The change to individual drive necessitated changes in the electric system and replacement of some equipment.

The single-phase current of normal frequency is led from the contact conductor to the phase converter, as was the case in the old system. The phase converter feeds a frequency converter which is an induction machine rigidly connected to the phase converter. By suitable switching, the frequency converter can be made into a 2- , 4- , or 6-pole machine. Its speed is constant at 1,500 rpm. Other data is as follows:

| Speed (km/hr) | 25 | 50 | 75 | 100 | 125 |
|---|---|---|---|---|---|
| No of poles | 2 | -- | 2 | 4 | 6 |
| Feed | To stator | -- | | To rotor | |
| Frequency (cps) | 25 | 50 | 75 | 100 | 125 |

The traction motors are connected to the frequency converter. With a 50-cycle supply, they are connected directly to the phase converter.

The locomotive is started using a water rheostat in the secondary circuit of the traction motors. Regulation of the rheostat resistance is performed automatically, as is the excitation of the phase converter, according to the power developed by the locomotive.

The traction motors are six-pole, three-phase induction machines for about 1,000 v. At 125 km/hr they rotate at 2,500 rpm. Each motor weights 1.8 tons and has an hourly rating of 640 hp. The suspension of the electric drives is of the streetcar type.

The locomotive can operate with regenerative braking, which cuts in automatically as soon as the speed exceeds the value set by the position of the controller. The connections between the phase converter, the frequency converter, and the traction motors are made by electropneumatic contactors.

Length and weight of car frames have been reduced to a minimum.

The main task set forth in designing this locomotive was to retain the advantages of the Kando system while achieving low maintenance cost and specific weight characteristic of those for dc or single-phase 16 2/3-cycle ac locomotives.

The new locomotive can be used for both passenger and freight trains.

On a 4% grade with a 1,500-ton train, it can attain a speed of 75 km/hr; with a 750-ton train, 125 km/hr.



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In view of the advantages of the new type of electric locomotive, the Hungarian State Railroads consider it the only type which satisfies all requirements in further electrification of their lines.

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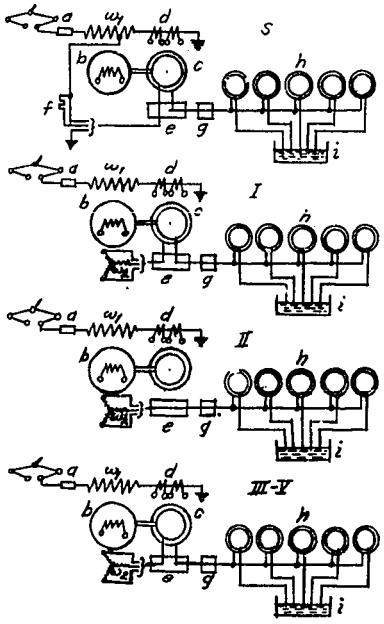


Main Wiring Diagrams for Power Circuits

S -- in starting: a, main circuit breaker; c, frequency converter; e, control equipment; g, reversing switch; h, traction motors; $\omega_1$, primary winding of phase converter; $\omega_2$, secondary winding of phase converter.

I-V -- running speeds: b, phase converters; d, instrument transformers; f, supplementary resistance; i, liquid rheostat.

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